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ABSTRACT

A set of elementary science preservice materials was developed and field-tested. The main objectives of these materials were to: (1) assist undergraduate elementary science methods students in developing a working definition of science and the scientific enterprise; (2) help students learn about effective questioning techniques; (3) introduce students to the learning cycle; and (4) demonstrate how the learning cycle can be applied to classroom instruction. The objective of this project was to determine the effectiveness of the preservice materials. This project included an evaluation of students' working definition of science, their understanding of effective questioning techniques in teaching, and their approach to developing science lessons. Forty-eight elementary education majors participated in this assessment. At the first class session of each methods course, the students were given a pretest to assess their background and knowledge in relation to the main objectives of the preservice materials. At the end of the semester, the students were given a posttest to assess how effectively the objectives of the preservice materials were met. The results indicated that after using the preservice materials, the students made significant gains in their knowledge of the nature of science and in the application of specific teaching techniques. (CW)

Assessing the Effectiveness of Instructional Materials Designed for Elementary Science Methods Students

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Paper presented at the National Association of Research in Science Teaching annual meeting in Lake of the Ozarks, MO, April 12, 1988.

ABSTRACT

A set of elementary science preservice materials was developed and field-tested during the 1986-87 academic year. The following year, these materials were evaluated to determine whether they had an impact on the professional preparation of elementary education majors. More specfically, these materials were evaluated to determine whether they helped students improve their knowledge of the nature of science, their understanding of effective questioning techniques, and their ability to apply the learning cycle in developing science lessons.

Forty eight (48) elementary education majors participated in this assessment. These students were enrolled in two different sections of Elementary Science Methods at Indiana University - Purdue University at Indianapolis. At the first class session, the students were given a pretest to assess their background and knowledge in relation to the main objectives of the preservice materials. At the end of the semester, these students were given a posttest to assess how effectively the objectives of the preservice materials were met.

The results of the pretest and posttest scores were analyzed using a T-test for correlated samples. The results of this analysis indicated that after using the preservice materials, the students made significant gains ($p = < .001$) in their knowledge of science and the application of specific teaching techniques, thereby suggesting that the objectives of the materials were met.

Introduction

In 1983, the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology recommended that preservice courses should include hands-on experiences, activities that enhance questioning, and should promote the development of creative and problem-solving skills. In the same year, the National Science Teachers Association (NSTA) made similiar recommendations about the preparation of elementary science teachers. Included in NSTA's recommendations were the statements that elementary science methods courses should contain hands-on experiences that aid in the development of process skills and that these courses should promote the selection of appropriate science topics for elementary students.

Using these recommendations as a guide, a set of elementary science preservice materials, titled SCIENCE, CHILDREN, & LEARNING was developed and field-tested (Barman, 1987). In addition, an INSTRUCTORS GUIDE was developed. This guide contains instructions about using the preservice materials and ancillary materials, such as visual aids, transparency masters, and hand-outs.

A Description of the Preservice Materials

SCIENCE, CHILDREN, & LEARNING consists of eight sequential modules which include hands-on activities, problem-solving exercises, and large and small group discussions. Table 1 displays an outline of the main ideas presented in each module.

(INSERT TABLE 1 ABOUT HERE)

The main objectives of these materials are: (1) to assist undergraduate elementary science methods students in developing a working definition of science and the scientific enterprise, (2) to help students learn about and practice effective questioning techniques, (3) to demonstrate how current learning theories apply to science teaching, (4) to introduce students to the learning cycle (Karplus, et. al., 1977), and (5) to demonstrate how the learning cycle can be applied to classroom instruction. The effectiveness of the learning cycle has been studied by several science educators. Their studies indicate that this strategy is an effective teaching method (Weber & Renner, 1972; Purser & Renner, 1983; Saunders and Shepardson, 1987).

It is also important to note that the eight modules emulate the learning cycle approach. Therefore, the preservice materials not only introduce the learning cycle and establish experiences for preservice students to practice it, but also provide a good classroom model of this approach.

Evaluation of the Preservice Materials

An evaluation of the preservice materials was conducted during the 1987-88 fall semester. The purpose of this evaluation was to determine whether these materials had an impact on the preparation of elementary education majors with regard to their knowledge of the nature of science, their understanding of effective questioning techniques, and their ability to apply the learning cycle to science lessons.

Forty eight (48) students participated in this assessment.

These students were enrolled in two different sections of Elementary Science Methods at Indiana University-Purdue University at Indianapolis. At the first class session, the students were given a pretest. At the end of the semester, they were given a postest. (The content and design of the posttest was similiar to the pretest.*)

To assess the homogeniety of variance of the two class sections, a one way analysis of variance (ANOVA) was conducted on the pretest and the posttest scores of each section. This statistical procedure verified that the two sections were homogeneous and, therefore, the two classes were combined and treated as one sample.

Content validity of the pretest and the posttest was determined by a panel of four judges possessing an expertise in either science education or evaluation techniques. The judges agreed that the items of the pretest and posttest contained similar content and that the items on both tests were at the same level of difficulty.

Reliability of the pretest and the posttest was established by administering these tests to a third section of elementary science methods students (N = 24). To reduce the possibility of any practice effects (Borg & Gall, 1971), both the pretest and the posttest were administered at the first class session.

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*A copy of the pretest and the posttest is included in the Appendix of this paper.

Alternate form reliability was established for both tests by calculating a coefficiency of equivalence. The alternate form reliability coefficient was found to be .72.

Results

The results of the pretest and posttest scores of the students participating in this evaluation were analyzed using a T-test for correlated samples (table 2). An analysis of the results of this statistical procedure indicates that after using the preservice materials the students made significant gains ($p = <.001$) in their knowledge of the nature of science and in the application of specific teaching techniques.

(INSERT TABLE 2 ABOUT HERE)

However, certain limitations should be placed on these findings. For example, the sample size is relatively small and it is possible that the students could have gained some of their knowledge from sources other than the preservice materials. Some of the students that participated in this evaluation were concurrently enrolled in other elementary methods courses. It is possible that some of the information and proficiencies they assimilated during the time of this assesment could be attributed to these courses.

Discussion

In addition to the above findings, I would like to include the following observations about the preservice materials. The students who field-tested these materials (Barman, 1987) and those who participated in this evaluation had very positive feelings toward the preservice materials. This information was obtained from final course evaluations. Some of the positive statements made by students were they felt the materials helped them gain a better understanding of science and how to teach it. The students also reported that they enjoyed doing the activities that are incorporated into each of the eight modules. Therefore, it appears that these preservice materials not only have a positive affect on student achievement but also nurture positive attitudes about science and science teaching.

Acknowledgements

I would like to thank Michael Cohen, Linda Furuness, and Jill Shedd for their helpful critique in the preparation of the pretest and posttest instruments. In addition, I would like to acknowledge the assistance I received from Golam Mannan and Kieth Morran in conducting the statistical analysis of this evaluation and the many hours of help that I received from Sandy Jessup in scoring the pretests and posttests and in compiling the data from this evaluation.

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Table 1

THE MAIN IDEAS PRESENTED IN EACH MODULE

Modules	Topics Presented in Each Module
1 - What is Science?	Identifies the processes of science, differentiates between science and technology, and discusses the societal implications of science
2 - Questioning Techniques	Discusses the importance of effective questioning techniques and provides an opportunity for an analysis of questioning strategies
3 - Solving Problems	An introduction to the way people solve problems
4 - The Reasoning Patterns of Children	Introduces the developmentalist model of learning and ways to assess reasoning patterns
5 - The Learning Process	Examines how people develop concepts
6 - The Learning Cycle	Introduces the learning cycle approach
7 - Developing Instructional Plans That Use the Learning Cycle	Demonstrates how the learning cycle can be applied to elementary science teaching
8 - Applying the Learning Cycle to Science Materials	Demonstrates how the learning cycle can be incorporated into existing science materials

Table 2

ANALYSIS OF PRETEST & POSTTEST SCO?ES

(T-test)

N = 48

	Mean	S.D.	D.F.	T Value	p
Pretest	21.6875	6.162	48	-9.72	0.000
Posttest	33.3958	5.073			

APPENDIX

(Pretest and Posttest)

E328 PREASSESSMENT

Identification Number ______________________________
(Social Security Number)

Have you already taken Q200? _____ If yes, when did you take Q200? _________

PLEASE NOTE: The purpose of this exercise is to determine your level of understanding of some science concepts and to gain information about some of the ideas you currently hold about teaching children. The results of this exercise will not in any way affect your grade in this course. Please read each item carefully and answer it to the best of your ability. Do not guess! If you are unfamiliar with certain terminology in a specific item, use the Unsure category. If you do not know the answer to an item, please check the Unsure category.

1. Read the following investigation that took place in an elementary classroom.

Materials Used in the Investigation: A roll of string, pendulum bobs of different mass, a meter stick, a scissors

The students were examining the question: Does the mass of the pendulum bob affect the rate at which a pendulum swings? In an attempt to answer this question, the students set up this hypothesis: The mass of the pendulum bob affects the rate at which a pendulum swings.

The class selected a variety of pendulum bobs that had different masses. In each trial, they attached a 60 cm string to a different bob and released it at a 10 degree angle. They counted the number of complete swings the pendulum made in 30 seconds.

The class ran several trials and recorded their observations. They then drew a conclusion based upon their findings.

2. Evaluate the above classroom investigation by checking the appropriate space following each statement.

	YES	NO	UNSURE
a) The students established an appropriate hypothesis.	_____	_____	_____
b) Each group manipulated one variable and held the other variables constant.	_____	_____	_____
c) The students conducted an investigation that could be repeated by other classes.	_____	_____	_____
d) The students in this class conducted an experiment.	_____	_____	_____

3. Two teachers were having a discussion in the faculty room. Teacher A was describing a science lesson that her students did last week. She explained that her students performed an experiment. They observed a chemical change by putting baking soda in vinegar. The other teacher (Teacher B) interrupted Teacher A and said that the students did not conduct an experiment. Instead, Teacher B said the students performed a science activity. Teacher A responded by saying that her students did perform an experiment. After all she said, an experiment must be able to be repeated and her students' investigation could easily be repeated.

a) Did Teacher A's class conduct an experiment? (Please indicate your choice in the space to the right.) _________

Please explain your rationale for either agreeing or disagreeing that Teacher A's class conducted an experiment.

____

____

____

____

____

4. For the next 5 items, please indicate whether you agree (A), disagree (D), or are unsure (U) about each statement by circling the appropriate letter.

	AGREE	DISAGREE	UNSURE
a) Piaget's theory applies to pre-school and primary grade students, but has little application to students in grades 3-6.	A	D	U
b) Open questions promote discussion and stimulate thinking.	A	D	U
c) Closed questions engage students in analysis, synthesis, and evaluation.	A	D	U
d) Teachers who wait 3-5 seconds after asking a question have found that the length and quality of their students' responses increases compared to those who wait .5 - 1 second.	A	D	U
e) One of the major objectives of an elementary science program is to provide students with the opportunity to develop and refine process skills, such as, observing, inferring, measuring, etc.	A	D	U

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5. The lesson that is attached to this exercise has been copied from a current elementary science series. Explain how you would use this lesson with elementary students. For example, identify the procedures you would use to present this lesson. You may list your lesson plan in an outline form.

MATTER CAN CHANGE

How does matter change?

Matter can change from one state to another. This kind of change is called a physical (fiz'ə kəl) change. Changes in size and shape are also physical changes. In a physical change, you have the same kind of matter before and after the change.

Water is matter. When water is poured, it is a liquid. If the water is put into a freezer, it changes to ice. If the water is heated enough, it will form a gas. Water in the form of a gas is called **water vapor** (vā'pər)


Changing size and shape


Liquid water and ice

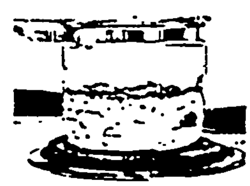
These changes in water show that matter can change from a liquid to a solid. It also shows that a liquid can change to a gas. Water may change from one state to another. But it is always water. It never changes to anything else.

Ice starts to form when water is cooled to zero degrees Celsius (sel sē əs) (The symbol for degrees Celsius is °C.) This temperature (tem pər ə chər) is the **freezing point** of water. At 0°C, the moving particles in water slow down to form ice. The water in this pond is frozen. How will the ice change on a warm day?[1]


Icicle melting


Frozen pond

Water starts to boil at 100°C. This temperature is the **boiling point** of water. As water boils, its particles move fast. They also move farther apart to form water vapor.


Water evaporating

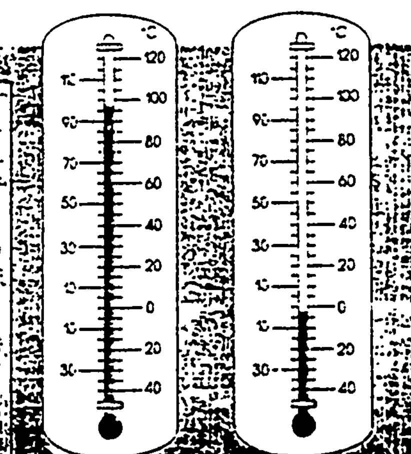

Water condensing

In the picture there is water vapor coming from the boiling water. This change from a liquid to a gas is called **evaporation** (i vap ə rā'shən). What will happen to the water as more and more vapor forms?[2]

The water vapor that is coming from the boiling water will cool. As it cools, it may change to a liquid. This kind of a change is called **condensation** (kon den sā'shən). If you breathe on a window, your breath will form tiny drops of water as it cools. This means that there is water vapor in your breath.

Do you know?

A thermometer (ther mom'ə tər) is used to measure the temperature. The liquid inside a thermometer rises when it is warm. And when it is cool, the liquid falls. Why does the liquid rise and fall as the temperature changes? Warm liquid takes up more space than cool liquid. As the liquid becomes warmer, its particles move farther apart and the liquid takes up more space.



Identification Number ______________________
(Social Security Number)

PLEASE NOTE: The purpose of this exercise is to assess specific components of E328. This exercise <u>will not</u> affect your grade. Please read each item carefully and answer it to the best of your ability. If you do not know the answer to an item, please check the <u>Unsure</u> category.

1. Read the following investigation that was conducted by students in an elementary school science class.

Materials Used in the Investigation: salt, water, graduate cylinder, cups, balance, teaspoons, clock with second hand

The students were examining the question: What affects how fast salt dissolves in water? In an attempt to answer this question, the students set up this hypothesis: The greater the quantity of salt, the longer it will take to dissolve.

The class used different amounts of salt (6, 12, 18, 24, and 30 grams). They added these amounts to five cups containing 250 ml of water (the water was the same temperature). As the salt was added to each cup, the water was stirred with a teaspoon until no salt crystals were observed in the water. The students recorded the amount of time it took for the salt to dissolve in each cup. (The total time interval recorded was - from the time salt was added to the cup until it was completely dissolved.)

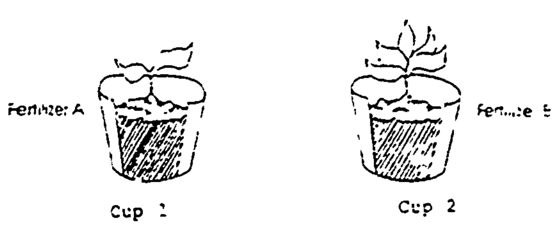
The class ran several trials of the above procedures and recorded their observations. Then, the students drew conclusions based upon their results.

2. Evaluate the above classroom investigation by checking the appropriate space following each statement

	YES	NO	UNSURE
a) The students established an appropriate hypothesis.	____	____	____
b) The students manipulated one variable and held the other variables constant.	____	____	____
c) The students conducted an investigation that could be repeated by other classes.	____	____	____
d) The students in this class conducted an experiment.	____	____	____

3. Mrs. Smith, a 5th grade teacher, asked each of her students to design and conduct an experiment. The following is a description of the work of one of her students.

Two types of fertilizers were tested to determine which one is best for growing bush beans. Two bush bean seeds were planted in each of the cups shown below.



Each cup contained the same amount and type of potting soil. Fertilizer "A" was added to cup 1 and fertilizer "B" was added to cup 2. Every third day, each cup was given 25 ml of water. Both cups were stored in a lighted area.

After four weeks, the height of the plants was measured. The plant in cup 2 was tallest. The student concluded that fertilizer B was the best for growing bush beans.

Does the student's activities demonstrate the components of an experiment? (Please answer this question by writing YES or NO in the space to the right.)

____

Next, please explain the rationale for your above answer.

____

____

____

4. For the next 5 items, please indicate whether you agree (A), disagree (D), or are unsure (U) about each statement by circl[ing] the appropriate letter.

	AGREE	DISAGREE	UN[SURE]
a) Piaget's theory is a helpful guide for early childhood education, but this theory has little relevance to students in grades 3-12.	A	D	
b) Open questions can engage students in analysis, synthesis, and evaluation.	A	D	
c) Closed questions promote discussion and critical thinking.	A	D	
d) Researchers have found that two (2) seconds is an ample amount of time for teachers to pause before they ask another question.	A	D	
e) A K-6 science curriculum should primarily focus on the development of specific science topics.	A	D	

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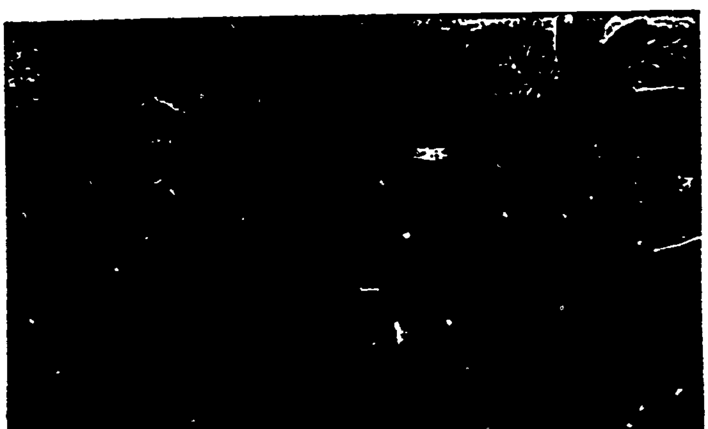
5. The lesson that is attached to this exercise has been copied from a current elementary science series. Explain how you would present this lesson with elementary students. For example, identify the procedures you would use to teach this lesson. Please list your lesson plan in an outline form on the back of this page.

ROOTS

What do roots do?

Have you ever tried to pull out weeds in a garden? Did they come out easily? Weeds and most other seed plants have roots that grow in the ground. In some plants, the roots may grow more than 6 meters deep. Roots hold plants in place. Look at these trees. Even a strong wind usually cannot blow them over.

What else do roots do? Roots take in the water and minerals (min'ər əls) plants need.

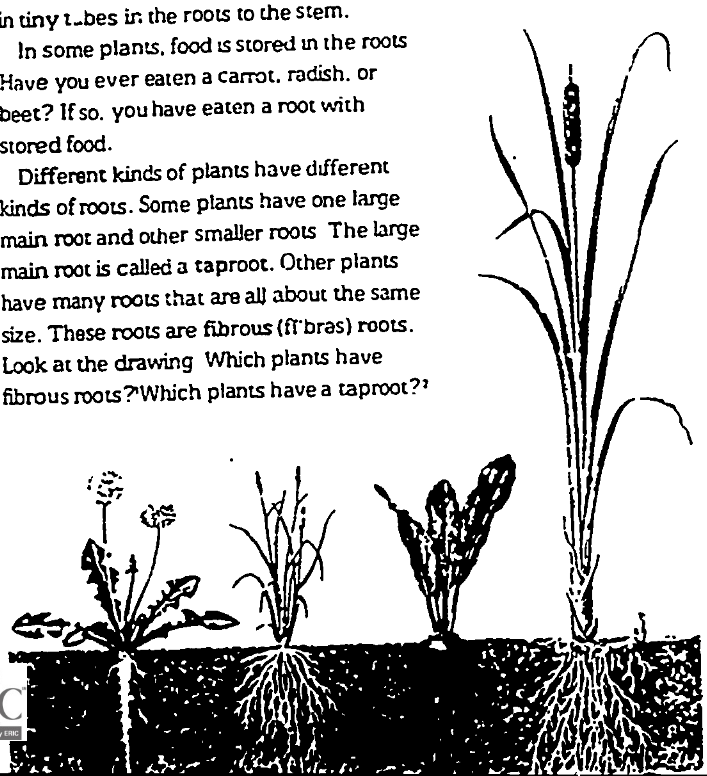


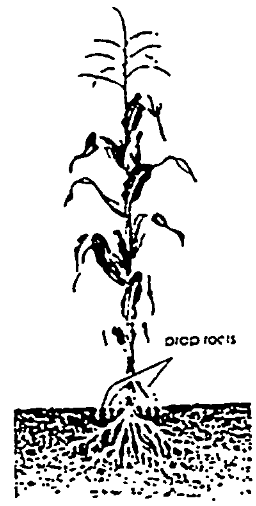
Palm trees in a storm

Plants need minerals to grow and to be healthy. The water and minerals are carried in tiny tubes in the roots to the stem.

In some plants, food is stored in the roots Have you ever eaten a carrot, radish, or beet? If so, you have eaten a root with stored food.

Different kinds of plants have different kinds of roots. Some plants have one large main root and other smaller roots The large main root is called a taproot. Other plants have many roots that are all about the same size. These roots are fibrous (fī'brəs) roots. Look at the drawing Which plants have fibrous roots? Which plants have a taproot?[2]





Another kind of root is the prop root. Prop roots are extra roots that grow out from the sides of stems. On some trees they grow downward from the tree branches. Corn plants and mangrove (mang'grōv) trees have prop roots. How do you think prop roots got that name?[3]

Mangrove trees